adjusting one image accordingly. The images are then compared, preferably volume element by volume element ("voxel by voxel") , to detect temporal differences between historical and later images. A composite image is displayed with synthetic colors or other visual clues to emphasize the scalars in the imaged tissue, based on temporal differences between the historical and later images.

Please replace the paragraph at page 5, line 16 through page 6, line 2 with the following:

Next, in step 52, pathological feature data is preferably loaded by the image processor 24 (preferably from a data network but alternatively by retrieval from storage or through another input channel). The pathological feature data is useful for narrowing the region of interest for image processing, and could be provided in any of several useful forms. Typically, a physical region of interest (ROI) in the historical image has been previously identified by a radiologist or other professional, and the coordinates of that region recorded in association with the historical image. In that case, the coordinates of the ROI are the pathological feature data. Alternatively, certain image shapes or characteristics, stored in a pathological image library, could be compared with the current image by image correlation to define the pathological region as described below in connection with FIGs. 6a -6c. A further alternative is to employ known automated methods for the detection of abnormalities in digital mammograms. For example, see U.S. Patent No. 5,491,627 to Zhang et al. (1996). The locations of any detected suspect lesions, as determined by such an automated method, could be used as the pathological feature data to identify and locate the ROI in the image.

Please replace the paragraph between page 6, line 30 and page 7, line 9 with the following:

Next, to obtain improved registration between the historical and new image, the image processor correlates the pathological feature set with the new image (step 58), preferably by the method described below in connection with FIGs. 5a and 5b. The information gained from the correlation operations allows better registration of the new image with the historical imagery and defines an ROI in the new image. This approach to 'better' registration provides for improved temporal difference resolution, and makes the associate measures more accurate within the region of interest. The ROI thus defined is then re-scanned (step 60), preferably as described above, with scanning ultrasound equipment but with a finer level of resolution. Finer resolution can be obtained by using slower scan speeds, higher frequency ultrasound, finer and more numerous receive sensors, or other techniques as known in the art. The fine scan, being preferably thus restricted to the ROI, can be executed in a shorter time than would be required to image the entire breast at a fine level of resolution.

A4

Please replace the paragraph between page 7, line 21 and page 8, line 4 with the following:

SUB B1

A5

After the historical and new images are aligned, they are compared in step 64 on a point-by-point basis, to obtain a temporal difference image which emphasizes the temporal changes which have occurred. A temporal difference image provides a scalar or reinforcement metric of learning, whereas a simple difference image simply determines whether or not a change has occurred. A temporal difference image is a reinforcement feedback signal indicating a scalar of how good/bad, how much change (vector), or how strongly (acceleration) an action is happening.

~~The scalars may represent, for example, a natural change, or the effectiveness of a treatment. For example, if digitized two dimensional images are considered, the images are preferably first normalized to a common average value, then corresponding pixels are subtracted and the temporal difference values stored in a corresponding position in a temporal difference image. Analogously, if three-dimensional imagery is available (which is greatly preferred), voxels at corresponding locations in the early and later images are subtracted one from the other, and the result stored in a voxel of a temporal difference (volume) image. (A "voxel" is a unit of graphic information that defines a small volume element in three-dimensional space. It is the three-dimensional analog of a "pixel" which defines an area element in two- dimensional space.) Thus, normalized before and after images can be subtractively compared, voxel-by-voxel, to obtain a three-dimensional temporal difference image which represents the temporal differences between the before and after images.~~

Please replace the paragraph at page 8, lines 5-25 with the following:

As a result of step 64, at least three images are available to the image processor 24: an early (historical) image; a current image; and a temporal difference image. These images are then combined and/or selected for display (step 66) in various ways, as directed by user input from input device 32. Finally, the resulting image or images are displayed (step 68) and preferably stored (step 70) and/or exported (step 72, preferably via the data network) . It is highly preferable that the imagery be coded to emphasize temporal differences between the earlier and later images. For example, the temporal difference image can be coded in a distinct color for display based on correlation output values, then superimposed on the early image, the later image, or a composite. Various other conventional methods could be

A6
CONT

equivalently employed to visually emphasize temporal image differences. For example, in one variation the temporal difference image can be displayed in intermittent, flickering display superimposed on either of the historical or current images. Significantly, the invention easily detects temporal differences between the earlier and later images, visually displays the images, and visually emphasizes these temporal differences.

Please replace the paragraph at page 9, lines 16-32 with the following:

A7

The success of the above described procedure depends in part upon the accuracy with which the earlier and later images are registered (in steps 56 and 62 of FIG. 2a and 2b) before comparison. Slight movement or deformation of the breast tissue or the scanning apparatus is to be expected between the earlier and later scans. The movement may include translation, rotation about any axis, or slight compression or expansion (in addition to biological tissue changes). To adequately register the images in step 56 or 62, therefore, a computationally practical and fast method of registration is preferred. A preferred method of registration takes advantage of the specific computational abilities of an optical correlator (discussed in detail below in connection with FIG. 9). This preferred method (suitable for use in step 64 of FIG. 2b) is best described with reference to an example of a particular coordinate system, to aid in visualization.

Please replace the paragraph at page 12, lines 25-37 with the following:

A8

As an alternative to collapsing the images by simple projection, as described above, a three-dimensional image can be processed to create a "discriminate filter." Such filters are

known and facilitate registration by providing a correlation filter which a composite of many images which differ by rotation about an axis. This allows testing of multiple, rotated slices simultaneously, by correlation with a composite discriminate filter. Once a discriminate filter is determined with acceptable correlation (at least equal to a pre-defined level of correlation) an individual filter is then selected from the set of slices which was used to compose the composite. In some cases, this method can greatly accelerate the search for best correlation.

A8 CON'T

Please replace the paragraph at page 18, lines 3-31 with the following:

A9

After the earlier and later ROI images are adjusted to best register them, they can be either combined by adding, voxel-by-voxel, or compared by subtracting, voxel-by-voxel. Temporal differences between the images are easily highlighted by changing the color at voxels which show high variation between the dual images. FIG. 8 shows an example of one typical display of a combined image (in this case, a composite of earlier and later images, with temporal differences highlighted). The outline of the breast 22 is shown, with highlighted suspected lesion 200 (simplified for illustration) as revealed by a recent ultrasonogram. Other more static regions of density 202 and 203 are shown, which would suitably be displayed in a neutral color or grey scale. The earlier lesion region 206 is surrounded by the later, larger lesion 200. Suitably the later region 200 would be highlighted, by example by display in a conspicuous color such as pink. The smaller lesion 206 (visible in the earlier historical image) would preferably be coded in a different color (for example, green). This three dimensional image, easily digitized and archived on computer readable media, provides easily readable documentation of the historical image

A9 CONT

changes, and can be retrieved for evidence of tissue changes. The image processor can also extract slices such as that cut by imaginary plane 302, and display the slice as a two-dimensional section for detailed inspection. Preferably, the processor is programmed to respond to user input so that any slice can be selected for display, or the user can sweep through multiple slices to view details of interest.

Please replace the paragraph between page 21, line 24 and page 22, line 1 with the following:

A10

When the input the filter images have been written to the input and filter ports 210 and 212, the optical correlator produces an output image which is a two dimensional output correlation pattern having an optical peak or peaks (bright spot) at the position of greatest correlation between the collapsed sonographic image and the radiographic image. The degree of correlation is indicated by the intensity of the output signal. The position of the output peak on the two-dimensional matrix of the correlator output CCD indicates the translations or shifts of the images relative to one another. The output image is read from the output photodetector (CCD) 214 by the image processor 24 in the conventional manner, typically by shifting the CCD voltage values out sequentially in rows (or columns) and then digitizing, the output levels. The peak amplitudes of the 2D array provide the extent of correlation (degree of correlation) between the images. This scalar information is a measure of the temporal difference, and can be used as a measure of knowledge between images and supports actions that lead to a successful treatment or evaluation.

Please replace the paragraph at page 29, lines 1-14 with the following:

An image processing system and method visually documents and displays changes between historical and later mammographic images, preferably in three dimensions. A composite image is created which visually emphasizes temporal differences between the historical and later images. Preferably three-dimensional, digitized images, displayable in various projections, are stored for archival purposes on computer readable media. An image processor preferably exploits an optical correlator to register the historical and later images accurately and provide correlation values as temporal scalars of the differences. The registered images are then compared, voxel-by-voxel, to detect temporal differences. The composite image is displayed with synthetic colors or other visual clues to emphasize apparent changes (for example, tumor growth or shrinkage).

A11

In the Claims

Please cancel claim 20.

Please amend claims 1, 9, 10, 11, 16 and 19 as follows:

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A12

1. (amended) A method of visually documenting historical changes in biological tissue, comprising the steps of:

(a) obtaining a first image of a region of tissue;

(b) after obtaining said first image, obtaining a second image of said region of tissue;

(c) digitally storing said first and second images as digitized first and second images;

(d) spatially adjusting at least one of said first and second digitized images to spatially register said images so that corresponding features in both images are mapped to corresponding positions; and

(e) creating from said first and second digitized images a

C1 CONT

A10 CONT

derived image which visually emphasizes temporal differences between said first and second images, thereby visually emphasizing historical changes between said images.

Sub C1

9. (amended) The method of claim 1, wherein said step of creating a composite image comprises:

comparing an image intensity at a location in said first image with a respective intensity at a corresponding location in said second image, and

determining a temporal difference image value based upon the temporal difference between said image intensity at said location in said first image and the respective intensity at said corresponding location in said second image.

A13

10. (amended) The method of claim 1, wherein said composite image visually emphasizes temporal image differences by representing various regions of said composite image in synthetic colors, based upon temporal image differences between the first and second images.

11. (amended) A method of creating a displayable composite mammographic image from a plurality of raw mammographic images, corresponding to earlier and later mammographic images, comprising the steps of:

(a) obtaining the earlier image of a region of tissue;

(b) obtaining the later image of substantially the same region of tissue;

(c) deriving a temporal difference image which represents changes between said earlier and later images; and

A13
CONT

(d) combining at least one of said earlier and later images with said temporal difference image, to produce a composite image.

A14

16. (amended) The method of claim 11, wherein said step of creating a composite image comprises:

spatially adjusting at least one of said earlier and later images to aid in registering said images.

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C1

A15

19. (amended) A system for enhancing imagery of bodily tissues by relating earlier and later images, comprising:

an image processor, programmed to: (a) receive said earlier and later images, (b) register the earlier and later images by controlling an optical correlator to find a position of correlation between said earlier and later images, (c) derive a composite image from the earlier and later images, (d) compute temporal differences between said earlier and later images, and (e) emphasize said temporal differences in said composite image; and

an optical correlator coupled to said image processor and arranged to correlate said earlier and later images, and to output to said image processor a cross correlation image which is indicative of the position of correlation of the processed images.

Add new claim 23 as follows:

A16

23. The method of claim 4, wherein said step of creating a composite image comprises:

comparing an image intensity at a location in said first image with a respective intensity at a corresponding location in said second image, and